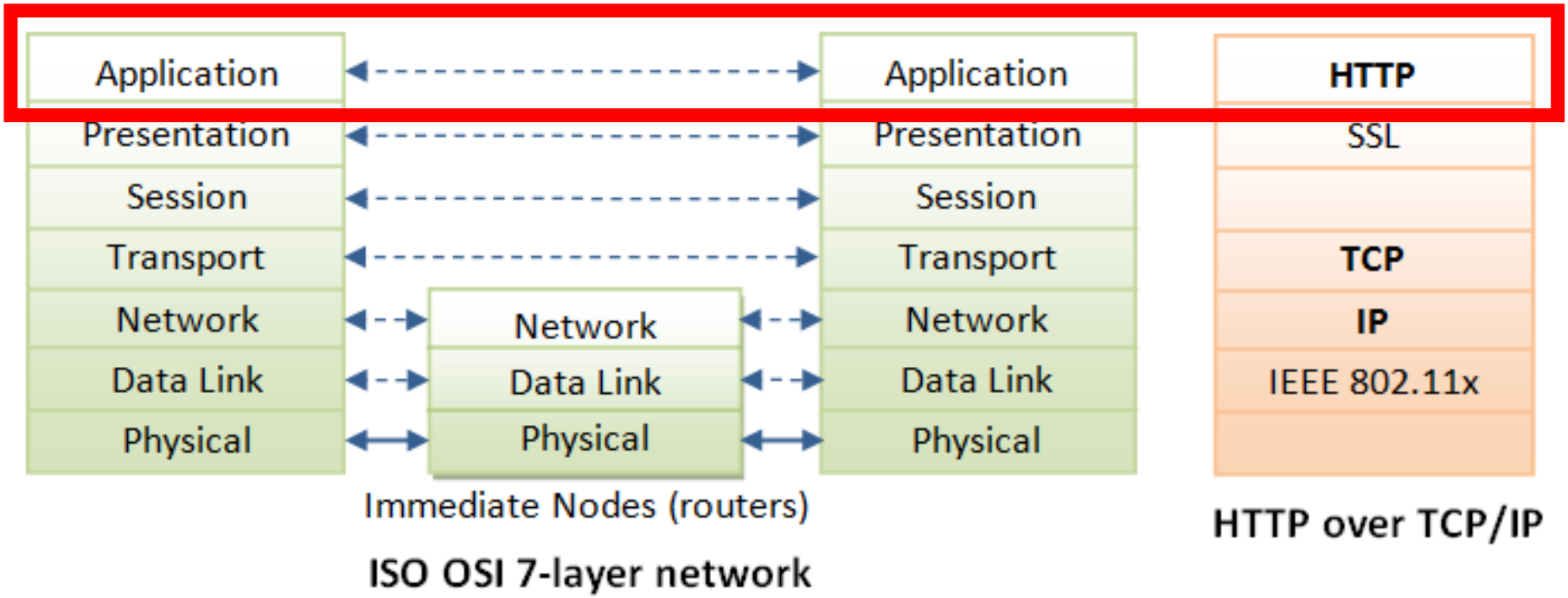
UNIZG-FER 222464

Web Architecture, Protocols, and Services

HTTP
The Driver of the World Wide Web

HTTP Basics

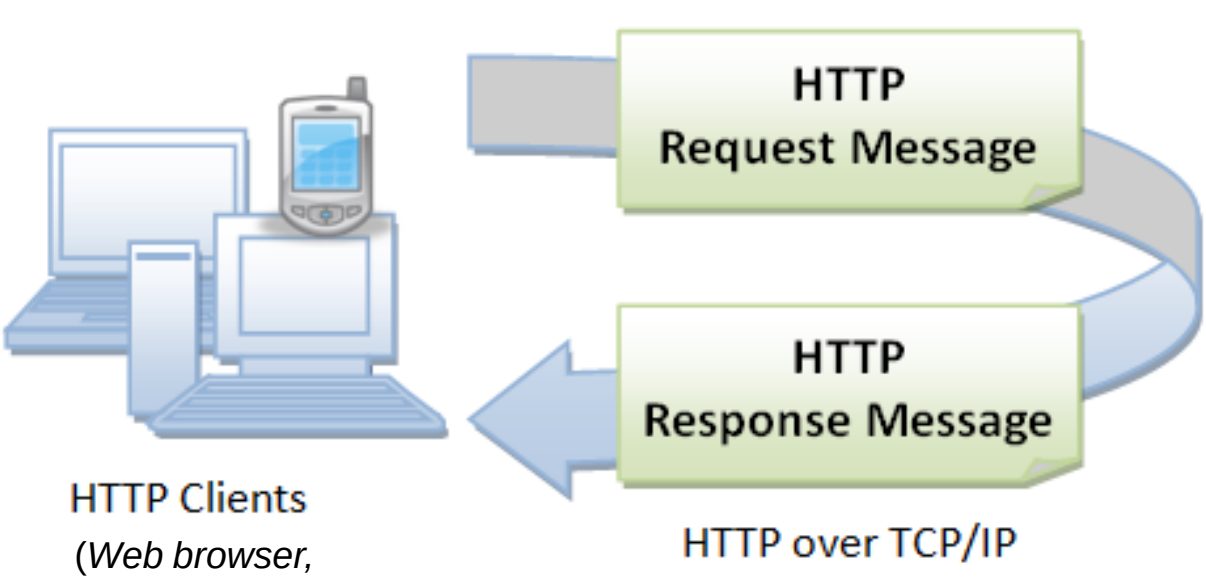
- HTTP (*HyperText Transfer Protocol*) protocol
  - Application-level protocol for distributed hypermedia information systems



- **World Wide Web**
  - Applications and services based on **HTTP protocol**

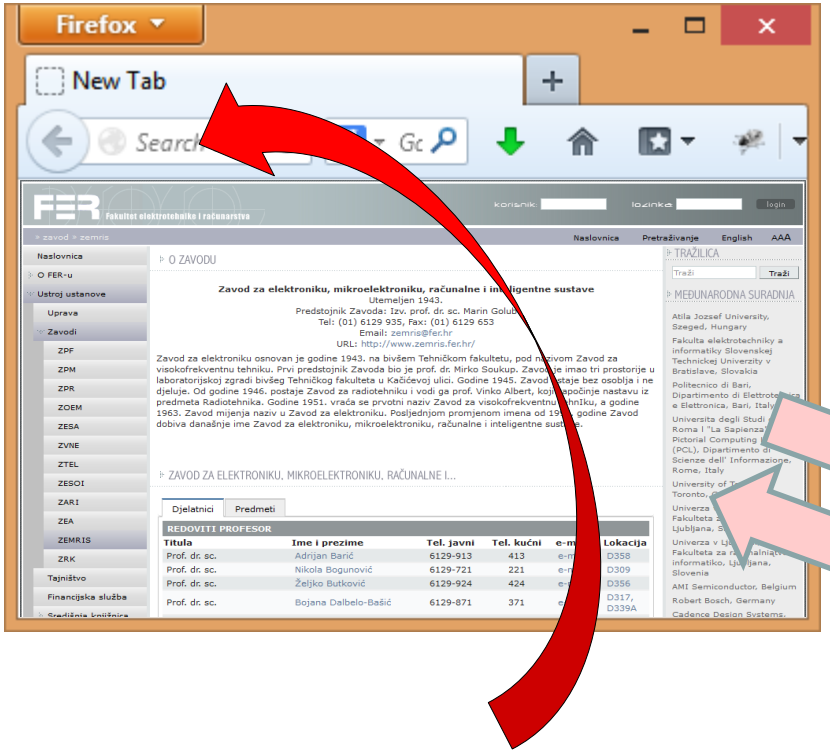
HTTP Basics

- HTTP (*HyperText Transfer Protocol*) protocol
  - Client-server architecture
  - Asymmetric request-response protocol
    - Client *pulls* information from the server
      (instead of server *pushes* information down to the client)



HTTP Basics

- Web browser
  - Most common HTTP client



DNS server
208.43.0.4

IP of www.fer.unizg.hr ?

161.53.72.120

Network connection (socket)

HTTP request: GET /predmet/apuw

HTTP response

HTML

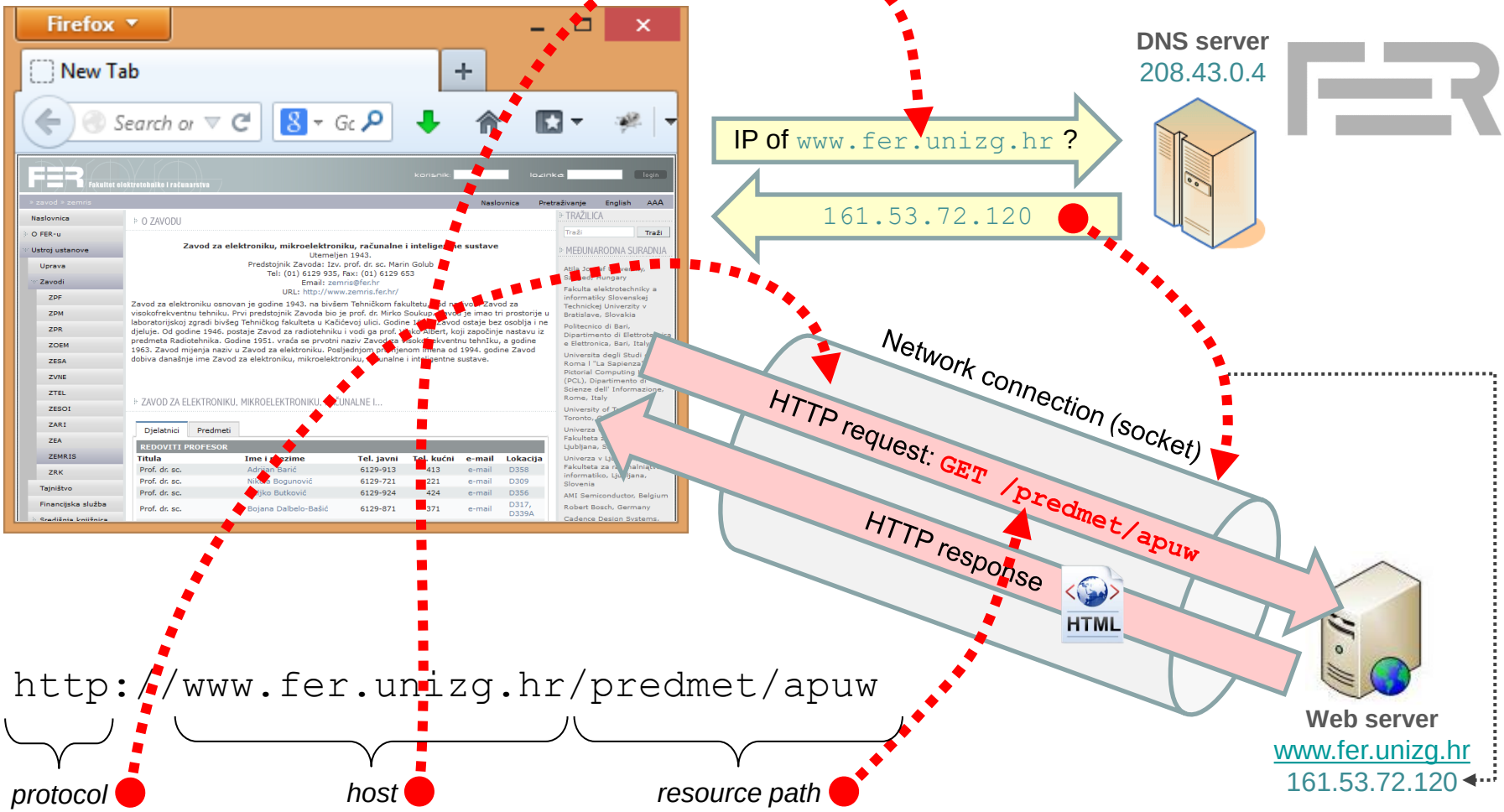
Web server
www.fer.unizg.hr
161.53.72.120

http://www.fer.unizg.hr/predmet/apuw

protocol *host* *resource path*

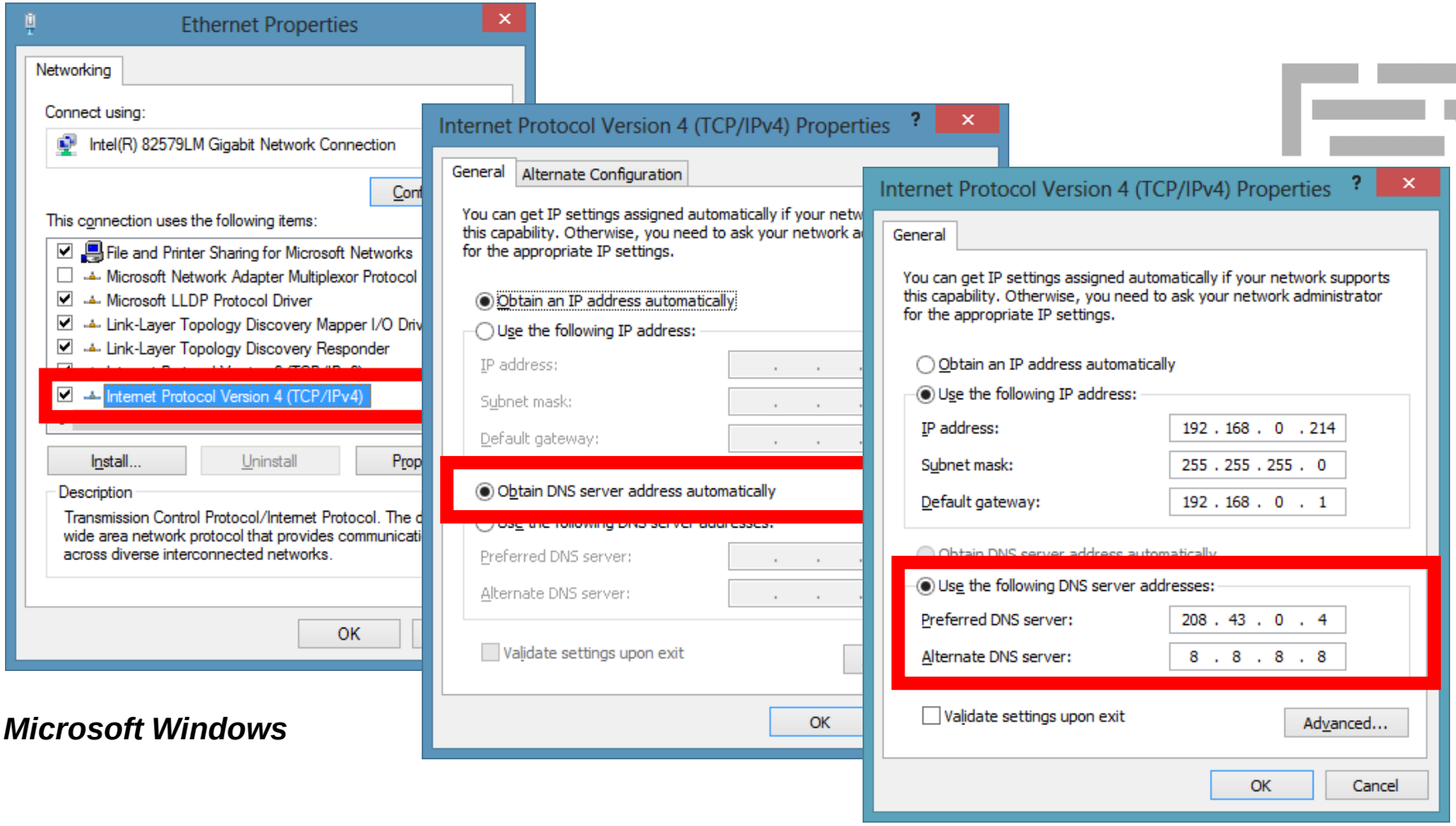
HTTP Basics

- Web browser
  - Most common HTTP client



HTTP Basics

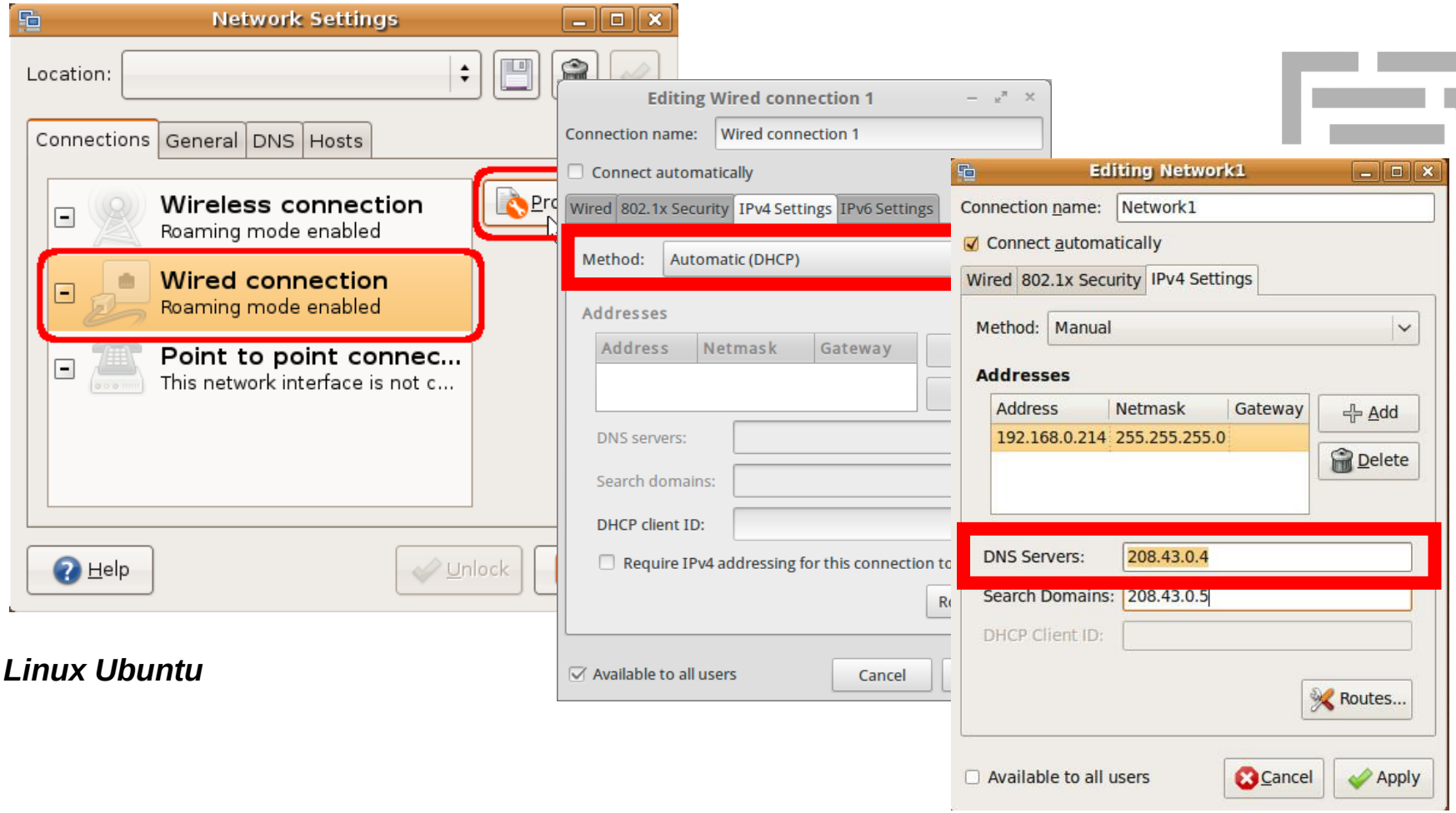
- How does a web browser find a DNS server?
  - Operating system network configuration



Microsoft Windows

HTTP Basics

- How does a web browser find a DNS server?
  - Operating system network configuration



Linux Ubuntu

HTTP Basics

- Uniform Resource Locator (URL)
  - String used to uniquely identify a resource on the web
- URL syntax

```
protocol://hostname:port/path-and-file-name?parameters
```

protocol

- Application-level protocol used by the client and server
  e.g. HTTP, HTTPS, FTP, telnet

hostname

- DNS domain name or IP address of the server
  e.g. www.fer.unizg.hr, 161.53.72.120

port

- TCP port number the server is listening on for incoming requests from clients

path-and-file-name

- Name and location of the requested resource under the server document base directory
  e.g. static file on disk or program that dynamically renders the response

parameters

- Optional, used to additionally describe the resource (*we'll come back to this later*)

HTTP Basics

- URL examples

1) `http://www.fer.unizg.hr/predmet/apuw` (default HTTP port is 80)
   `http://www.fer.unizg.hr:80/predmet/apuw`
   `http://161.53.72.120/predmet/apuw`
   `http://161.53.72.120:80/predmet/apuw`

2) `http://www.example.com:1234/europe/croatia/home.html`

3) `https://www.fer.unizg.hr/predmet/apuw` (default HTTPS port is 443)
   `https://www.fer.unizg.hr:443/predmet/apuw`

4) `https://www.fer.unizg.hr:987/predmet/apuw`

5) `ftp://www.ftp.org/docs/test.txt` (default FTP port is 21)

6) `telnet://www.test101.com/` (default TELNET port is 23)

HTTP Basics

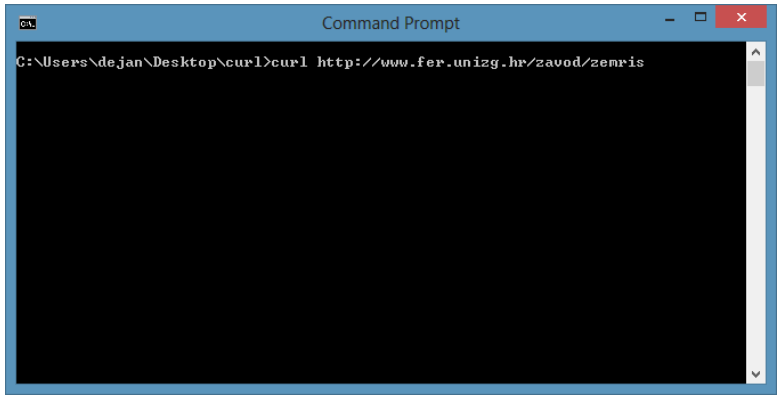
General HTTP client algorithm

1. Client takes URL as input (*given by user or set programmatically*)
2. Client parses the URL
    3. Client asks the DNS server for web server's IP address
    4. DNS server responds with IP address

    (*steps 3 and 4 are not necessary if user enters web server's IP address instead of DNS name*)
5. Client opens a network connection to a given IP address and TCP port
6. Client sends an HTTP request message to the web server
7. Server maps the *resource path* part of the URL to a local file or program
8. Server returns an HTTP response message
9. Client processes the response (*e.g. web browser renders GUI and displays a web page to the user*)

HTTP Basics

- Other HTTP clients
  - `curl`



  - Command line syntax

    ```
    curl [options] <url>
    ```

  - Usage instructions

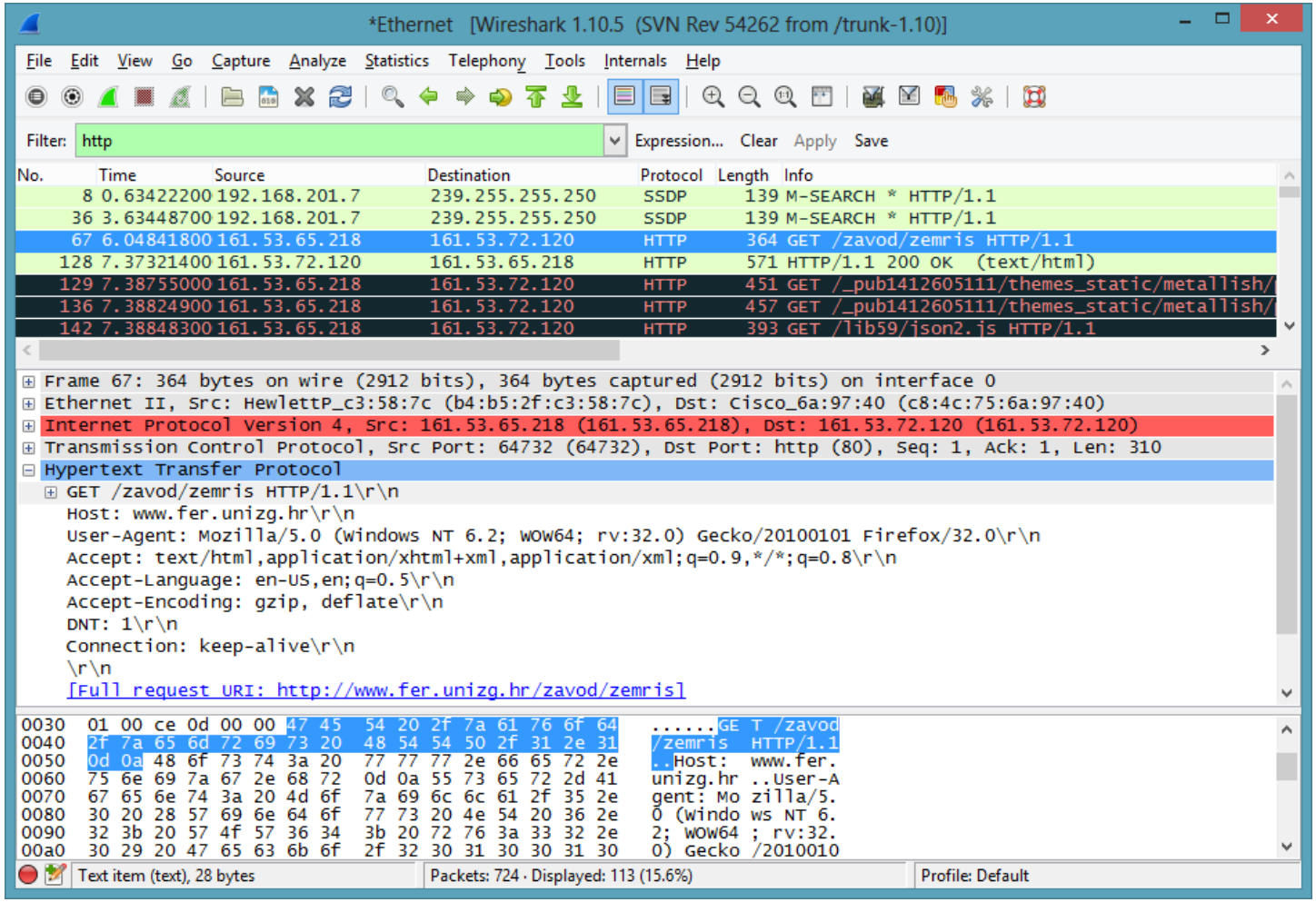
    ```
    curl -help
    ```

  - Simple HTTP request

    ```
    curl http://www.fer.unizg.hr/predmet/apuw
    curl https://www.fer.unizg.hr/predmet/apuw
    ```

HTTP Basics

- What happens on the network level?
  - Network monitoring & capture tool



HTTP Basics

- What happens on the network level?

HTTP request message

Web browser (Firefox)

```
GET /predmet/apuw HTTP/1.1
Host: www.fer.unizg.hr
User-Agent: Mozilla/5.0 (Windows NT 6.2; WOW64; rv:23.0) Gecko/20100101 Firefox/23.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
DNT: 1
Cookie: __utma=161902635.17065694.1374136092.1377600687.1377615217.13; __utmz=...
Connection: keep-alive
```

curl

```
GET /predmet/apuw HTTP/1.1
User-Agent: curl/7.32.0
Host: www.fer.unizg.hr
Accept: */*
```

HTTP Basics

- What happens on the network level?

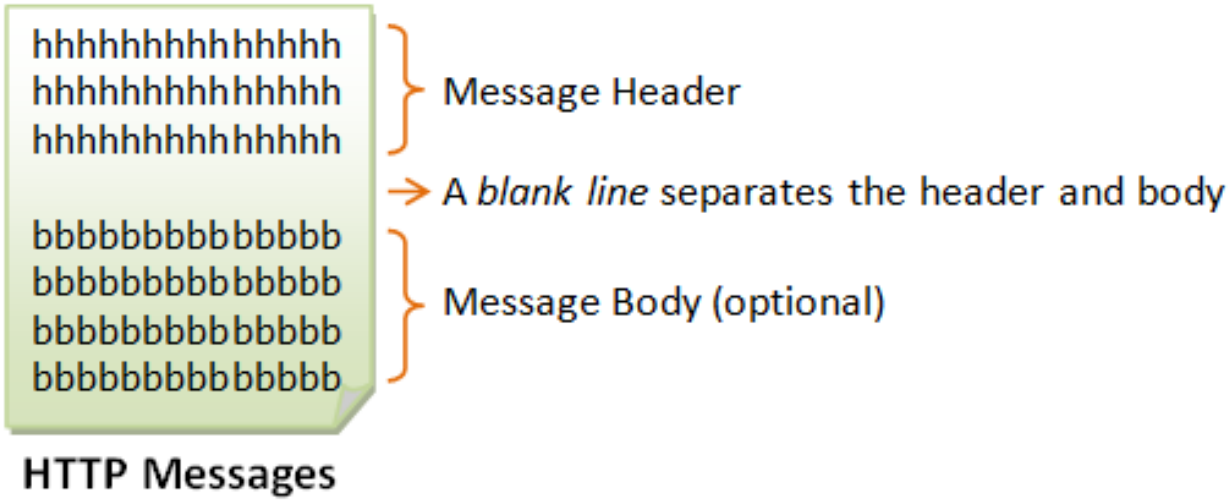
HTTP response message

```
HTTP/1.1 200 OK
Date: Wed, 14 Oct 2021 10:49:28 GMT
Server: Apache/2.2.23 (FreeBSD) mod_fcgid/2.3.6 mod_ssl/2.2.23 OpenSSL/0.9.8x
X-Powered-By: PHP/5.3.19
Expires: Thu, 19 Nov 1981 08:52:00 GMT
Cache-Control: no-store, no-cache, must-revalidate, post-check=0, pre-check=0
Pragma: no-cache
P3P: CP="NOI CURa ADMa DEVa TAIa PSAa PSDa IVAa IVDa HISa OTPa ..."
Set-Cookie: CMS=vhtenqteedgso8d9u618h8vgq6; expires=Wed, 04-Sep-2013...
Content-Length: 73120
Content-Type: text/html; charset=utf-8

<!DOCTYPE HTML><html lang="hr" class="htmlcms"><head><meta http-equiv="Content-
Type" content="text/html; charset=utf-8" /><meta http-equiv="Content-Language"
content="hr" /><meta name="generator" content="Quilt CMS 2.5,
https://www.fer.unizg.hr/quilt-cms" /><!--meta name="robots" content="noindex"
/--><meta name="keywords" content="" /><title>Arhitektura, protokoli i usluge
weba</title><!-- breaks jquery-ui-1.10.3 tabs --><!--base
href="https://www.fer.unizg.hr/predmet/rznu"--><link rel="alternate"
type="application/rss+xml" title="FER: Računarstvo zasnovano na uslugama"
href="/feed/rss.php?url=/predmet/rznu" ><link rel="alternate"
type="application/rss+xml" title="FER News: Računarstvo zasnovano na uslugama"
href="/feed/rss.php?url=/predmet/rznu&amp;portlet=news" >...
```

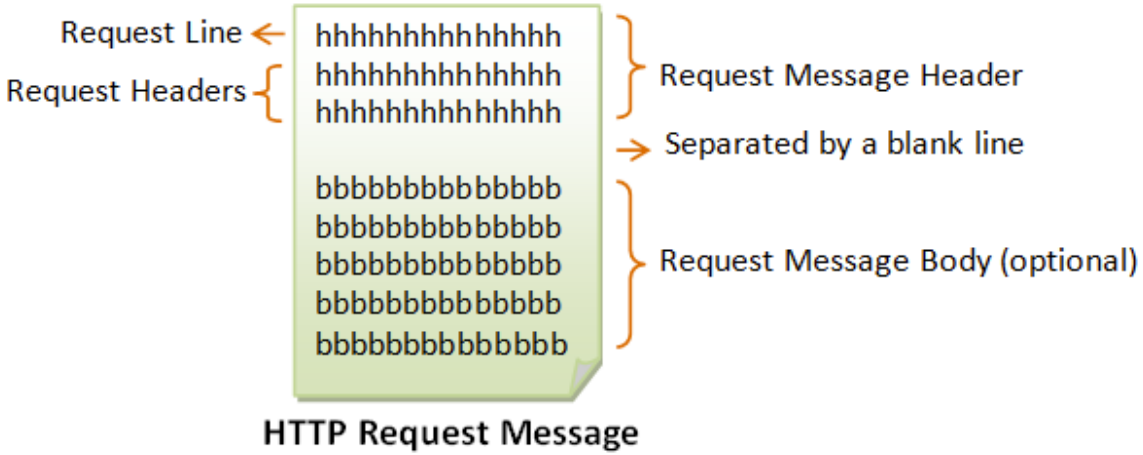
HTTP Basics

- HTTP messages
  - General form
  - Each HTTP message (either request or response) follows this general form

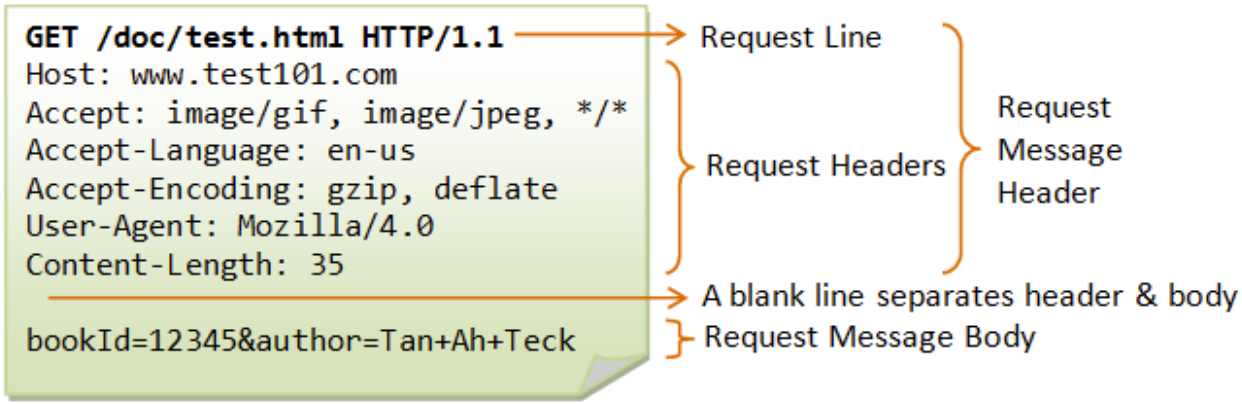


HTTP Basics

- HTTP request message

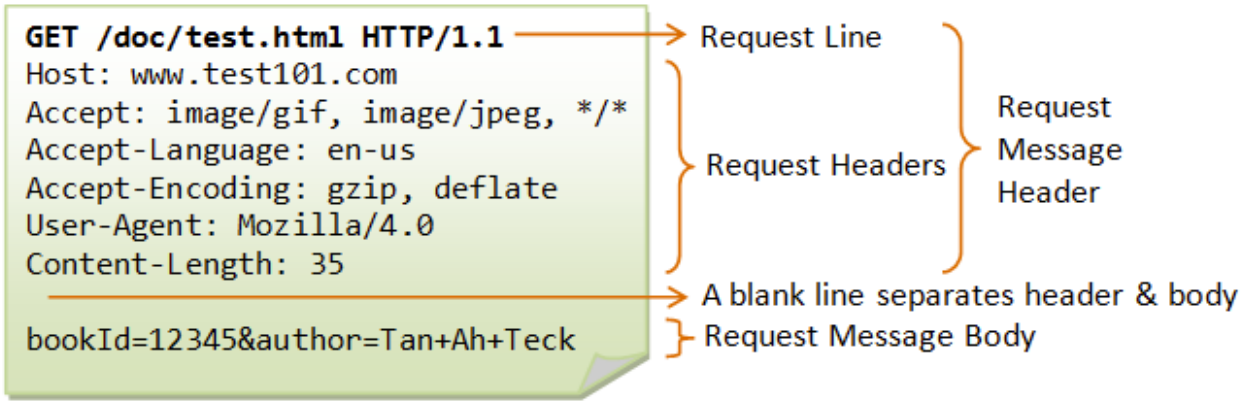


Example:



HTTP Basics

- HTTP request message



Request line:

`request-method-name  request-URL  HTTP-version  CRLF`

`request-method-name`

Informs the server which operation to perform over the resource
HTTP protocol defines a set of request methods: `GET`, `PUT`, `POST`, `DELETE`, `HEAD`, and `OPTIONS`
The client uses one of these methods to send a request to the server

`request-URL`

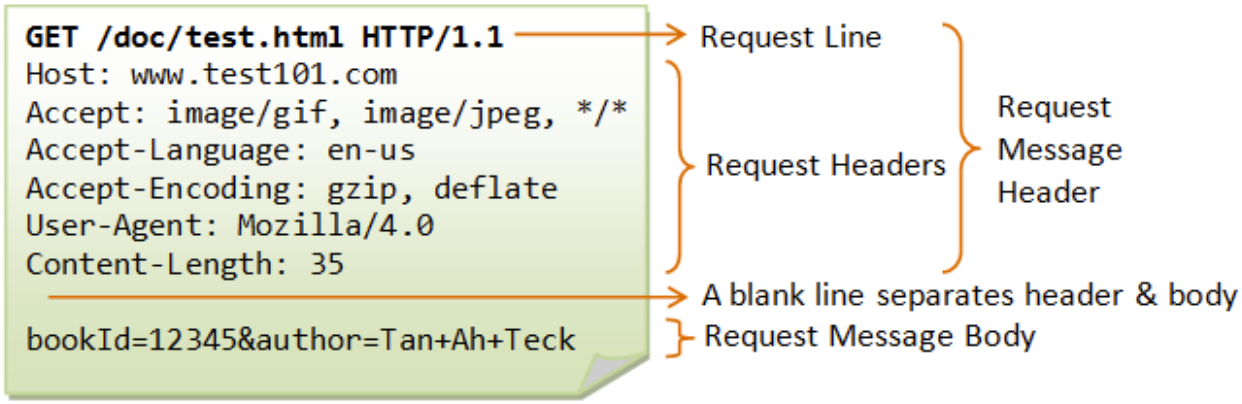
Specifies the resource on a web server over which the server should perform the requested operation

`HTTP-version`

Client specifies the version of HTTP protocol it understands
Two versions are currently in use: `HTTP/1.0` and `HTTP/1.1` (recent `HTTP/2` uses binary framing instead)

HTTP Basics

- HTTP request message



Request line:

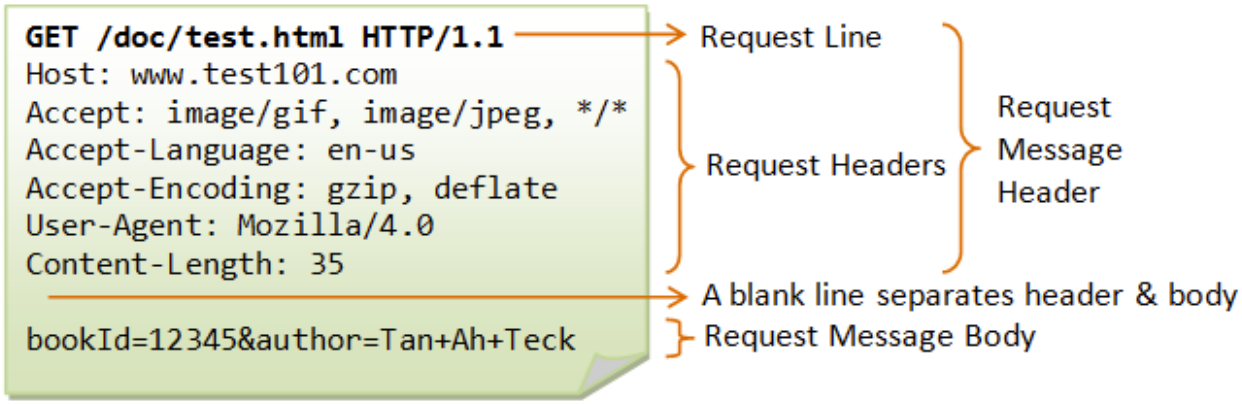
`request-method-name  request-URL  HTTP-version  CRLF`

Examples:

```
GET /predmet/apuw HTTP/1.1
GET /predmet/apuw HTTP/1.0
HEAD /predmet/apuw HTTP/1.1
PUT /photoalbum/image03.jpg HTTP/1.0
DELETE /photoalbum/image03.jpg HTTP/1.0
POST /news/article/comments HTTP/1.1
```

HTTP Basics

- HTTP request message



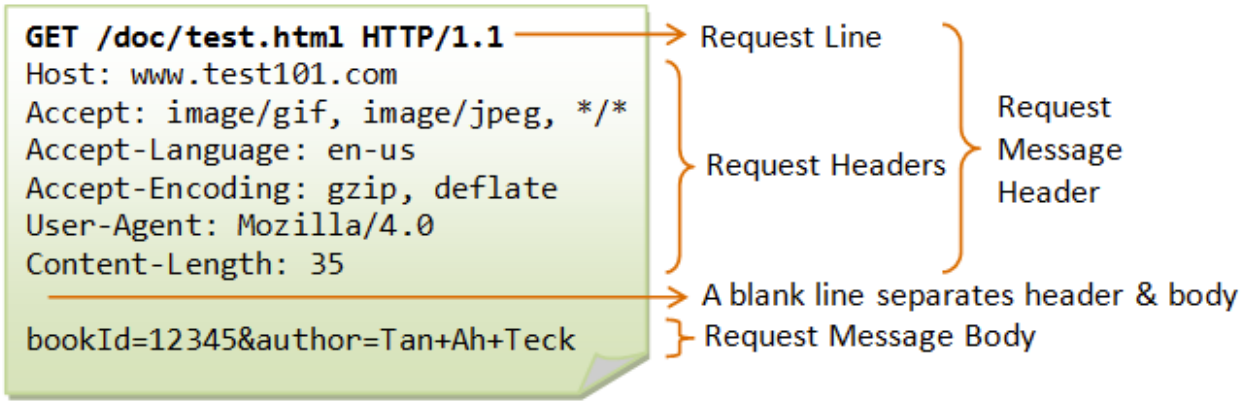
Request header:

`request-header-name: request-header-value1, request-header-value2, ... CRLF`

- The request headers are in the form of `name: value` pairs
- Multiple header values, separated by commas, can be specified
- Each request header ends with a new line (`CRLF`)
- HTTP allows arbitrary number of request headers in single request
- HTTP also allows custom non-standard header names
  (*custom web servers might process custom headers, standard web servers ignore them*)

HTTP Basics

- HTTP request message



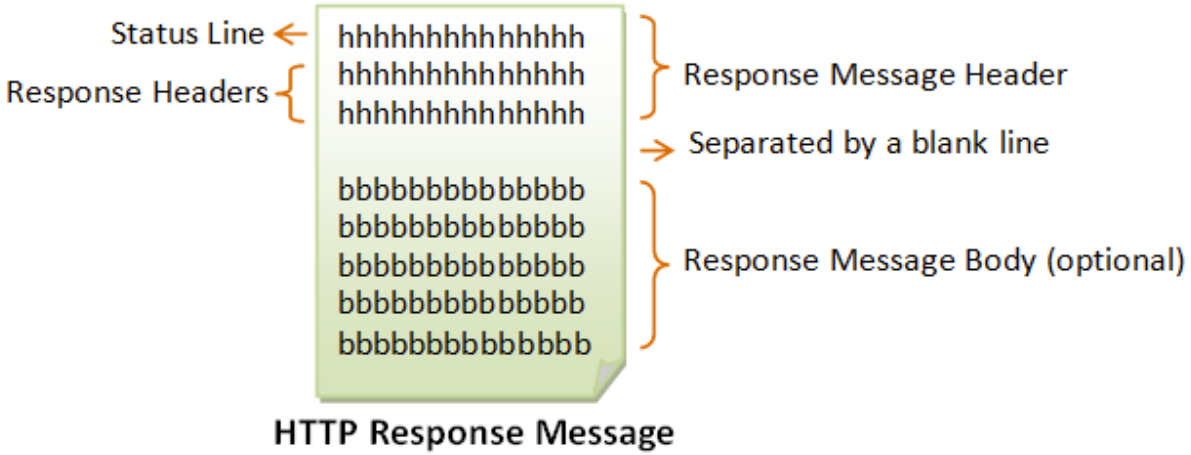
Request message body:

no defined structure, free format, arbitrary length

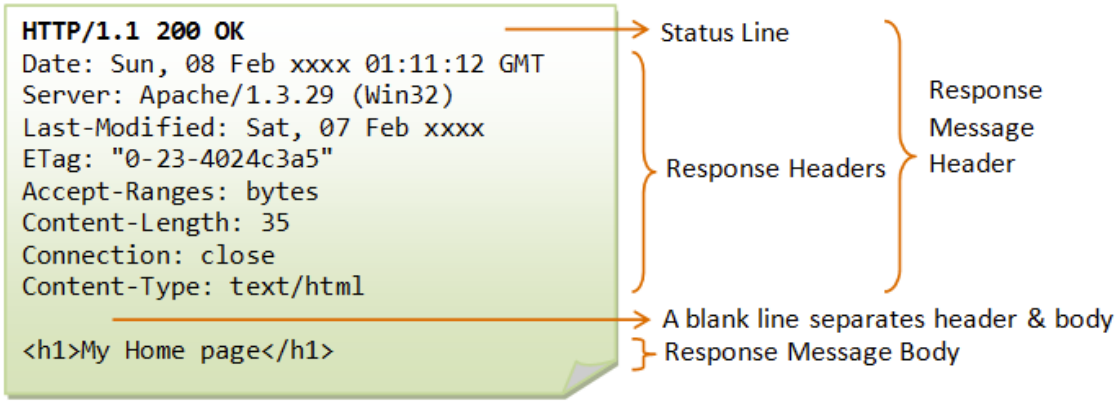
- Optional part of HTTP request message
- Used to send extra data with the request that cannot be specified in request headers (*for example, user-defined parameters*)
- HTTP protocol does not define the structure of request message body
- HTTP headers specify how to interpret the body (*for example,* `Content-Type` *header*)

HTTP Basics

- HTTP response message

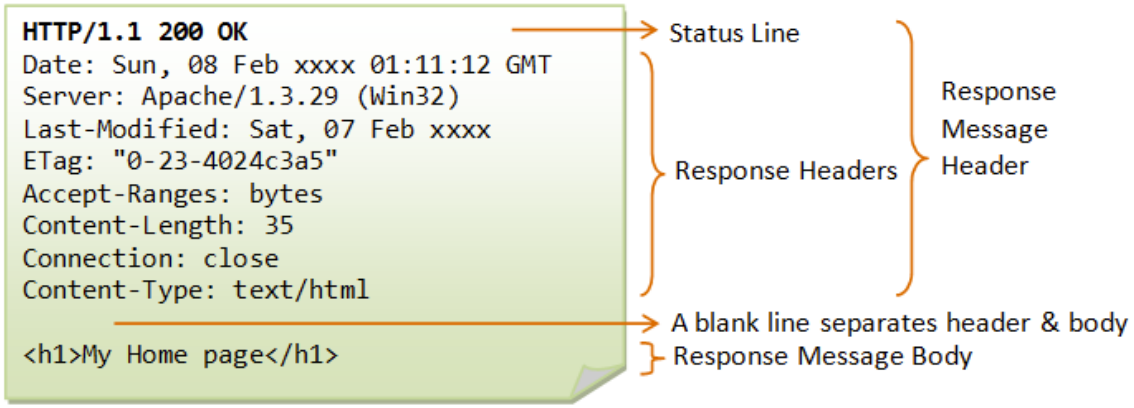


Example:



HTTP Basics

- HTTP response message



Status line:

`HTTP-version  status-code  reason-phrase  CRLF`

`HTTP-version`

Server specifies the version of the HTTP protocol used in response
Version chosen by server should be equal or lower than the version specified in client's request
Two versions are currently in use: `HTTP/1.0` and `HTTP/1.1` (recent `HTTP/2` uses binary framing instead)

`status-code`

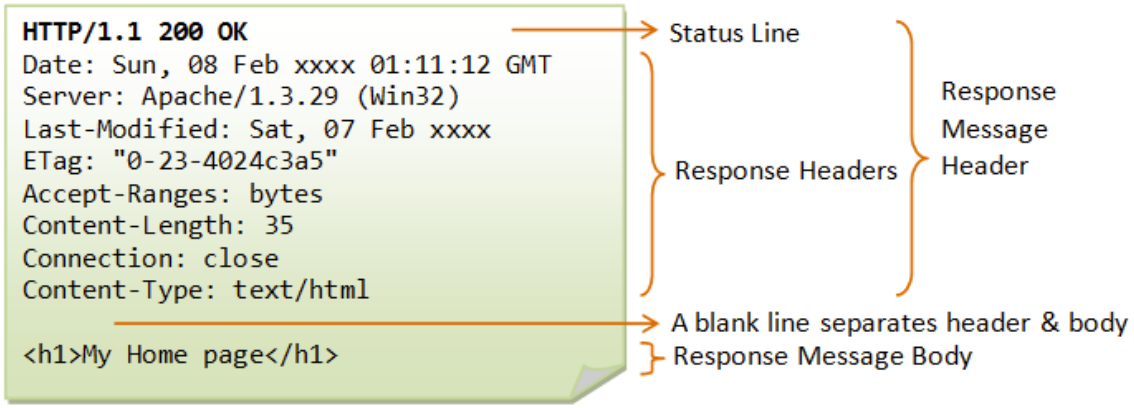
A 3-digit number generated by the server to reflect the outcome of the request
Informs the client whether request is served successfully, some error occurred, etc.

`reason-phrase`

Gives a short explanation to the status code

HTTP Basics

- HTTP response message



Status line:

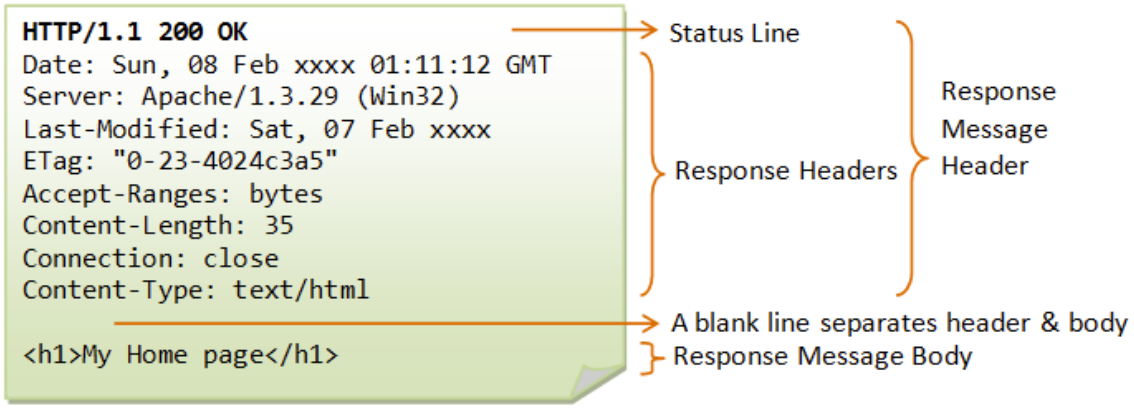
`HTTP-version  status-code  reason-phrase  CRLF`

Examples:

```
HTTP/1.1 200 OK
HTTP/1.0 404 Not Found
HTTP/1.1 403 Forbidden
HTTP/1.1 500 Internal Server Error
```

HTTP Basics

- HTTP response message



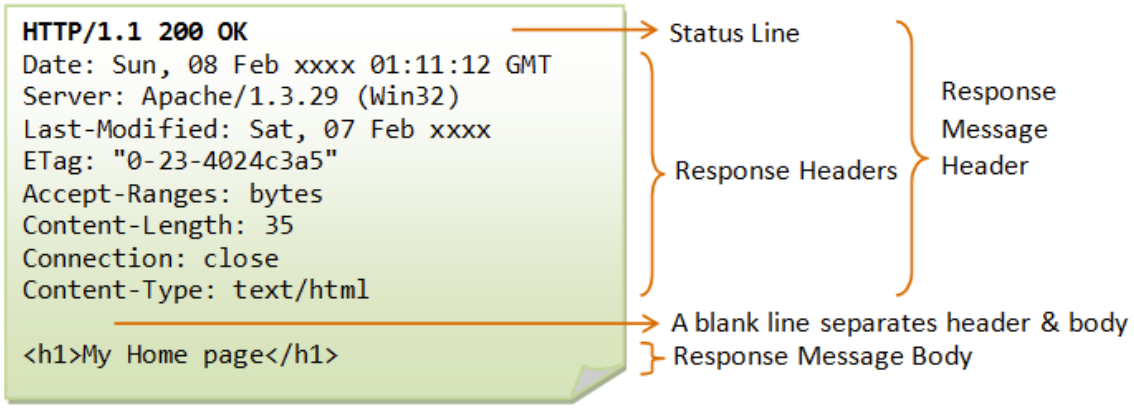
Response header:

`response-header-name: resp-header-value1, resp-header-value2, ... CRLF`

- Response headers follow the same form as request headers
  - The response headers are in the form of `name: value` pairs
  - Multiple header values, separated by commas, can be specified
  - Each response header ends with a new line (`CRLF`)
  - HTTP allows arbitrary number of response headers in single request
  - HTTP also allows custom non-standard header names
    (*custom clients might process custom headers, standard HTTP clients ignore them*)

HTTP Basics

- HTTP response message



Response message body:

no defined structure, free format, arbitrary length

- Optional part of HTTP response message
- Used to send data from web server back to the client
  (*for example, web page's HTML, client-side script, image*)
- HTTP protocol does not define the structure of response message body
- HTTP response headers specify how to interpret the body
  (*for example,* `Content-Type` *header*)

HTTP Basics

- HTTP client socket-level programming

```
import java.net.*;
import java.io.*;

public class HttpClientSocket {
  public static void main(String[] args) throws IOException {
    // The host and port to be connected
    String host = "www.fer.unizg.hr";
    int port = 80;
    // Create a TCP socket and connect to the host:port
    Socket socket = new Socket(host, port);

    // Create the input and output streams for the network socket
    BufferedReader in = new BufferedReader(new InputStreamReader(socket.getInputStream()));
    PrintWriter out = new PrintWriter(socket.getOutputStream(), true);

    // Create request line
    out.println("GET /predmet/apuw HTTP/1.1");
    // Add some request headers
    out.println("Host: www.unizg.fer.hr");
    out.println("User-Agent: My custom HTTP client");
    // Add blank line separating header & body
    out.println();
    // Send request to the HTTP server
    out.flush();

    // Read the response and display on console
    String line;
    // readLine() returns null if server closes the network socket
    while((line = in.readLine()) != null) {
      System.out.println(line);
    }
    // Close the I/O streams
    in.close();
    out.close();
   }
}
```

HTTP Basics

- HTTP client socket-level programming
  - Compile program

```
javac HttpClientSocket.java
```

  - Start program

```
java HttpClientSocket
```

HTTP Basics

- HTTP client programming using HTTP library

```
import java.net.*;
import java.io.*;

public class HttpClientHttpLib {
  public static void main(String[] args) throws IOException {
    // The URL of the remote resource
    String url = "http://www.fer.unizg.hr/predmet/apuw";
    // Open a TCP connection for HTTP communication with a resource with given URL
    HttpURLConnection http = (HttpURLConnection) new URL(url).openConnection();

    // Read response status
    System.out.println("Response status code: " + http.getResponseCode());
    System.out.println("Response reason phrase: " + http.getResponseMessage());
    System.out.println();

    // Read response data if any
    String line;
    BufferedReader in = new BufferedReader(new InputStreamReader(http.getInputStream()));
    while((line = in.readLine()) != null) {
      System.out.println(line);
    }

    // Close the connection
    http.disconnect();
  }
}
```

HTTP Basics

- HTTP client programming using HTTP library
  - Compile program

```
javac HttpClientHttpLib.java
```

  - Start program

```
java HttpClientHttpLib
```